Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE CORDILLERAN MESOZOIC REVOLUTION.

CERTAIN features connected with the occurrence of plutonic rocks on the western side of America suggest hypotheses which have an important bearing upon our general conceptions of the structural development of the continent. These features are but imperfectly and very partially recorded thus far in geological literature, owing to the vastness of the field and the meagre amount of investigation which has been devoted to it. Yet enough facts have been accumulated to have impressed the writer that they point to generalizations which have not yet been fully presented for the consideration of students of continental problems. To formulate these generalizations is the object of this brief note. It is not the purpose of the writer to add to the record of facts so much as to connote the more important of them and to suggest their cumulative significance.

The researches of Richardson[1] and Dawson[2] on the coast and islands of British Columbia have shown that the Cretaceous rocks of that region, ranging from the *Aucella* bearing horizon (Neocomian) to the Chico, repose upon a profoundly eroded complex of granite and metamorphic rocks. The disturbances which have affected these Cretaceous strata since their deposition have been of a local rather than of a regional character. They lie upon the old basement usually in but little disturbed attitudes, or are inclined at low angles, though occasionally they are faulted or sharply folded along certain lines of post-Cretaceous movement. The same condition seems to generally characterize the more elevated early Cretaceous rock of the British Columbian interior along the cañon of the Fraser river. Jurassic rocks have been described from British Columbia, but the Geological Survey of Canada has since come to the conclusion that these rocks are

---

[1] Reports of Progress, Geol. Survey of Canada, 1871–2, 1872–3, 1873–4, 1874–5, 1876–7.

[2] Report of Progress, Geol. Survey of Canada, 1878–9. Annual Report (New Series) Vol. II., 1886. Geol. Survey of Canada, Report B.

Cretaceous.[1] If the Jurassic exists on the west coast of British Columbia, it must occupy very limited areas or be involved in the pre-Cretaceous metamorphic complex. The fossils collected in the less altered portions of this complex by Richardson and Dawson, show the presence of Triassic and Carboniferous formations, but no undoubted Jurassic forms have yet been detected. It therefore seems that the erosion to which the region was subjected prior to the deposition of the Cretaceous was effected in Jurassic time. As Dawson has shown,[2] this erosion was of longer duration in the southern part of the province than in the northern, and the transgression of the Cretaceous sedimentation was from north to south.

The further studies of Dawson upon the pre-Cretaceous complex of granite and metamorphics have been fruitful of most interesting and important results. Prior to his researches the granite (and granite-gneisses) of the region were generally regarded as the equivalent of the Laurentian of the east. It was shown,[3] however, by him that the basement upon which the now metamorphic sedimentary and volcanic strata of the Vancouver series (Triassic, with probably some Carboniferous), was deposited is non-existent, and has been replaced by an immense mass of intrusive granite, which has absorbed by fusion all rocks below the present remnants of the Vancouver series, and has invaded the latter after the manner of an irruptive magma. This post-Triassic granitic batholite is of enormous dimensions. In the fall of 1890 the writer had an opportunity of examining it cursorily for a distance in a straight line of over five hundred miles, in and out of the fiords of the coast from Burrard Inlet to Alaska; and the granite is known to extend far northward into that territory. Its width may be placed at from sixty to one hundred miles. In the portion examined there are several masses or belts of schistose metamorphic rocks which have been sunk down into the granite, but they form a small proportion of the entire complex. The granite varies somewhat in mineralogical composition, texture, and structure, and is often distinctly gneissic locally. In places it is essentially hornblendic, in others it is micaceous. Notwithstanding these variations, which are common in most large granite masses, the granite seems to be a unit throughout, and the mass is certainly a very important factor in the epeirogeny of the west coast of America. Even should it be discovered by the closer scrutiny which science will certainly demand, that there are portions of an older granite terrane to be discriminated from the general mass, the conclusion will not be invalidated, that in the interval between the deposition of Triassic strata and the deposition of lower Cretaceous, the earth's crust was in this region invaded by an immense batholitic magma, hundreds of miles in extent, which absorbed a large part of the pre-Triassic basement, as well as a portion of the Triassic rocks themselves. This invasion of the crust by the British Columbian batholite seems to have conditioned a general and pronounced elevation of the coast. For the erosion which intervened before the deposition of the Cretaceous was possessed of a vigor only born of lofty mountains, removing the upper crust and cutting down deep into the congealed granite. The Cretaceous rocks were littoral deposits at the base of these lofty mountains. Thus was a great revolution wrought in the geology and physiography of the west coast of British Columbia in the interval between the Triassic and Cretaceous times.

---

[1] Sketch of the Geology of British Columbia, by G. M. Dawson, Geol. Mag., April and May, 1881.

[2] Am. Jour. Sci., Vol. xxxix., March, 1890.

[3] Annual Report (New Series), Vol. ii., 1886, Geol. Survey of Canada, Report B, pp. 10-13.

Little is definitely known of the geology of the Olympic Mountains, but it is probable that the conditions which prevail on Vancouver Island, which is the northern extension of the range, hold good here, the Cretaceous rocks of the coast reposing upon the lower flanks of mountains which consist of a complex of granite and metamorphic rocks. These mountains are probably the least known portion of the United States, and they are mentioned here simply to indicate that important evidence bearing upon the phenomena here discussed is likely to be found in that region.

In southern Oregon, on the line of the Southern Pacific Railway, the writer has on several occasions observed the eruptive contact of an extensive granite mass against sedimentary strata which have been mapped as "Auriferous slates," which are probably early Mesozoic or Carboniferous in age. The intrusion of the granite into the sedimentary rocks is unquestionable, the relations being well exhibited in the excellent exposures afforded by the railway cuttings.

In California the statements of Whitney[1] and the more recent writings of the geologists of the U. S. Geological Survey, Diller, Becker, Turner, and Lindgren, and of Mr. H. W. Fairbanks, seem to leave no room for doubt that a great part, probably the greater part, of the granitoid rocks of the Sierra Nevada is of Mesozoic age, and has invaded the now more or less altered sedimentary and volcanic rocks known as the "Auriferous slates," which range in age from the Silurian up to the Jurassic.

Here again we have clearly to deal with a granitic batholite which must, by absorption or otherwise, have replaced a large portion of the preëxisting lower rocks in the region affected. From the facts recorded by able and critical observers, this conclusion holds, notwithstanding the probability that there may also be remnants of an older granite to be discriminated from the Mesozoic mass. In the southern Sierra, as Becker has, with wise caution, pointed out, we approach the region of Archæan granite known in the Grand Cañon section. It would therefore be not at all remarkable to find these more ancient granites involved with the newer in the Sierra Nevada. But their presence could not affect the important fact of an invasion of the crust during middle Mesozoic time by an immense granitic batholite, which invasion without doubt had much to do with the metamorphism of the strata which survived the upward progress of the magma into the crust.

Here again the development of the batholite seems to have conditioned the uplift and wide-spread disturbance which is freely recognized in geological literature as having occurred at the close of the Jurassic. Again we have, as in British Columbia, a wonderful dissolving of the ancient *status quo*, a revolution of no mean import, whether regarded merely as an historical event or in its bearing upon the general principles of epeirogeny. The important feature which distinguishes the group of facts observed in the Sierra Nevada from those in British Columbia is that in the former we have the Jurassic a part of the great assemblage of rocks invaded by the granite while in British Columbia these rocks are not known to exist. This difference, taken together with the probable fact that the pre-Cretaceous denudation of the Sierra was less profound than that of British Columbia, suggests a progressive development of the batholitic condition from north to south, so that the disturbance was felt somewhat later in California, although it was part, doubtless, of the same great subcrustal process.

---

[1] Geology of California, Vol. I. Auriferous Gravels.

In the Coast Ranges of California we have much less precise information than in the case of the Sierra Nevada. Analogous conditions seem to be indicated by the information at hand. There are areas of granite and metamorphic rocks which have been subject to great denudation prior to the deposition of the Cretaceous. No rocks of older age than Cretaceous are known to rest upon the worn surface of this complex. Carboniferous fossils have recently been found by Mr. Fairbanks in the Santa Ana Range[1] in a series of rocks into which the granite of the region has been injected. The same geologist informs us of the intrusion of the granite of the Gavilan Range[2] into the Coast Range metamorphics, and of similar relations in the Trinity Mountains in the Northern part of the state.[3] The writer, also, has observed that the granite of the Santa Cruz Range is intrusive in the limestone of the metamorphic complex. Mr. Fairbanks is of the opinion that generally the granite of the Coast Ranges is the equivalent of that of the Sierra, but direct evidence of its intrusion into Triassic or Jurassic strata has not yet been adduced. All that can safely be asserted at present, in the opinion of the writer, is that in the Coast Ranges there is a pre-Cretaceous complex of granite and metamorphic rocks analogous to that of the Sierra Nevada; and that there is no evidence yet recorded which is adverse to Mr. Fairbank's correlation of the granites of the two regions.

---

[1] Am. Geologist, vol. xi., Feb., 1893.

[2] Loc. cit.

[3] Am. Geologist, March, 1892.

In Mexico the official map shows conditions which resemble those of the Sierra Nevada. Emerging from beneath the volcanic sheets, or the mantles of Tertiary or Quaternary formations there are, along the western side of the Republic, numerous masses of granite rocks with associated metamorphics. In these metamorphic rocks are occasional patches of Jurassic and Triassic, conservatively limited in the mapping doubtless to the actual areas where fossils have been found to so determine their age. These small patches of known Jurassic and Triassic age are suggestive of the proximate limit in age of the metamorphic series, and yielding to analogy we may be allowed to *suppose* that the granite bears a relation to the Mexican metamorphics similar to that exhibited in the Sierra Nevada of California.

In South America Steinmann[1] calls attention to the important fact of the invasion of the Mesozoic strata of the Cordillera by truly granitic and dioritic rocks. Karsten,[2] also, informs us that in Columbia, Venezuela and Ecuador the Jurassic are the oldest sedimentary rocks, but have been found at only one locality, while the Cretaceous and Tertiary are abundantly developed; and that the underlying basement upon which the Cretaceous rests is largely granitic. Putting Steinmann's and Karsten's information together we seem clearly to have the conditions of British Columbia and California repeated as to the development of a granitic batholite in the Cordilleran belt in pre-

---

[1] Am. Naturalist, Oct. 1891.

[2] Geologie de l'Ancienne Colombie Bolivarienne, Nouvelle Grenada et Ecuador, par Hermann Karsten, Berlin.

Cretaceous Mesozoic time, followed by continental uplift and great denudation.

From the facts above cited certain conclusions seem to be warranted which may be presented in the form of hypotheses for future examination:

(1) The pre-Cretaceous Mesozoic revolution which has been freely recognized by nearly all Californian geologists was not limited to the western United States, but affected the entire extent of the Cordilleran belt from Alaska to South America.

(2) It is not clear that the revolution was strictly synchronous in all portions of the Cordilleran belt which have been affected. It may have been progressive, and have extended through the time from the close of the Triassic to the close of the Jurassic so as to obliterate the Jurassic seas earlier in some regions than in others.

(3) An essential feature of the revolution was the development of batholitic magmas which invaded the crust, replaced large portions of it, and eventually congealed as plutonic rock of a prevailingly rather acid character.

(4) The development of the batholite, or batholites, was followed or accompanied by continental uplift.

(5) The complex of invading granite and consequent metamorphics is analogous to that of the Archæan and indicates that the conditions which are commonly recognized as Archæan are not peculiar to rocks of that age.

By way of addendum to this brief note it should be remarked that the irruption of granite in South America did not wholly cease with the Mesozoic revolution. Farther south than the countries which have been mentioned, in the Cordillera of the Argentine Republic, Stelzner has shown that this phase of crustal development continued through into the Tertiary. After a narration and discussion of his facts he formulates the following conclusion:

"So mit bleibt denn nur noch die Annahme übrig, dass die als Granite, Syenite und Diorite zu bezeichnenden Andengesteine eruptive Gebilde sind, die theils nach der Jura- und Kreidezeit,

z. Th. sogar erst nach der in der Tertiärzeit erfolgten Ablagerung der buntscheckigen Andesittuffe im gluthflüssigen Zustande emporgestiegen sind und diejenigen Lagerungsverhältnisse eingenommen haben, unter welchen wir sie heute beobachten können."[1]

ANDREW C. LAWSON.

BERKELEY, July 15, 1893.

---

[1] Beitrage zur Geol. und Palaeont. der Argentinischen Republic, I. Geol. Theil, p. 207.